Identifying Optimal Solutions for Wastewater Treatment in the Pharmaceutical Industry

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Ever since concerns about the potential risks of pharmaceutical pollution were raised in the late 1990s, environmental authorities have addressed the issue and introduced policies that are continuously updated and strictly enforced. But the appropriate treatment of wastewater accrued during the operation of pharmaceutical manufacturing facilities still poses a challenge for the industry, because generic treatment methods are unable to remove trace amounts of pharmaceuticals which might end up in the effluent water.

Naturally, because of the constant exposure, aquatic life has a higher risk to be negatively affected: While some anti-inflammatory drug was shown to damage the gills and lungs of fish, some hormones or compounds that mimic properties of hormones are capable of feminizing or masculinizing them and pose a threat to their population. Water scarcity in some areas resulted in the practice of wastewater re-use, exposing humans to trace amounts of pharmaceuticals as well.

The industry understands the negative impact of water contamination all too well and is committed to protect the environment and comply with the continuously updated standards. But generic methods, designed to address a wide range of potential waste, are not applicable to their specific needs. Pharmaceutical Wastewater (PWW) is often mixed with other types of waste and the type and amount of the manufactured drugs is different for each facility. As a result, PWW has diverse characteristics and varies e.g. in terms of BOD, specific drug residues and pH-value, requiring treatment methods that are specifically targeting certain types of waste.

Existing Solutions for Pharmaceutical Wastewater Treatment

Instead of developing entirely new approaches, it might be a valid strategy to find a workaround based on existing solutions – and save both time and money as a result. This would include to explore already-operating plants and identify the best available technology for a similar project. Some of the conventional methods (which can be differentiated into physical, chemical, biological and thermal treatment) remove at least certain pharmaceuticals and might already be sufficient.

Activated Sludge Process is a common (biological treatment) method that leverages microorganisms to degrade organic compounds in the wastewater. But the ability to break down the pollutant varies. Drugs like sulfamethoxazole (antibiotic), ibuprofen and acetylsalicylic acid (a breakdown product of Aspirin) degrade within 2 -5 days up to 98%; antiepileptic like gabapentin at least partially degrade. Roxithromycin (antibiotic) on the other hand, needs 5- 10 days to degrade, while drugs like Carbamazepine (anti antiepileptic drug) and Diazepam (psychoactive drug) have shown no significant degradation even after 20 days. Therefore, alternative methods are required to destroy trace amount of toxic drugs in the wastewater.

Another viable solution for PWW treatment is an advanced *membrane* process to remove or concentrate the drugs from the wastewater. Two widely used membrane technology are Nano Filtration and Reverse Osmosis. Again, the effectiveness varies depending on the characteristics of the waste in question. With a pore size of 0.002 micrometers (2nm), a typical Nano Filtration filter is able to remove most organic substances, almost all viruses, other organic molecules and a range of salts but lacks when it comes to rejecting pollutants with a lower molecular weight. Those can be addressed by using the pressure-driven membrane filtration called Reverse Osmosis (typical filter pore size of 0.1nm). A *membrane process* has a lower footprint, is quick to build with standardized ready-to-use system available and therefore easier to accommodate in existing facilities. However, both the equipment and its energy-intensive operation are costly and this treatment is not a destruction process but merely separates and concentrates the pollutant. Some kind of destruction process (thermal/chemical/aerobic oxidation) is required to remove it afterwards and the concentrate needs to be hauled out or evaporated for a zero liquid discharge.

An Advanced Oxidation Process (AOP) is a method that either destructs the pollutant or converts non-biodegradable into biodegradable. AOP is an answer to most refractory drugs that escape aerobic oxidation, chemical oxidation or membrane process.

Based on the characteristics of the drug residue in the wastewater, multiple treatment options are available. But each of them brings its own advantages and disadvantages: They address only certain types of waste and might have to be combined to effectively prevent water contamination. Or they are expensive to implement and operate – even though parts of the investment might be recovered by recycling the water for non-critical processes. Especially when upgrading existing facilities, space constraints have to be taken into account as well.

From Identification to Testing to Implementation

Since there is no one-stop solution applicable to every type of pharmaceutical manufacturing facility, the "Best Available Technology" has to be identified to ensure the protection of the environment and a certain return on investment. From both a technical and a business perspective plenty of variables have to be taken into account before implementing a commercial system, requiring a phased execution plan and tests in a real-world environment. From Exyte's perspective, the development path for each facility has to include an evaluation of both the existing systems and the characteristics of the PWW and a pilot test system to estimate cost and performance, identify potential operational problems and evaluate the requirements of a full-scale, automated solution.

Exyte is able to provide the full scope of services required for such projects: analyzing the environmental situation and conducting a process study, developing a concept and later a detailed design, undertake the necessary constructions and installations and even commissioning and certifying the complete system. Leveraging its global network of engineers and technologists, located in all major regions (APAC, EMEA, AMER) and well-connected with equipment manufacturers and technology providers, Exyte can identify, test and finally implement an optimal solution for each project.

Regulations often enough don’t leave much of a choice anyway, but the protection of the environment in which we live and work should be in our all best interest. Exyte is committed to this protection and feels well positioned to support our client’s efforts in this regard with a complete scope of services and global enginee-ring expertise.